

Phase II Project Summary

Firm: Michigan Aerospace Corporation

Contract Number: NNX09CB25C

Project Title: Fabry-Perot Based Ranging Interferometer Receiver for High Resolution Lidar: HSRL Phase II

Identification and Significance of Innovation: (Limit 200 words or 2,000 characters whichever is less)

NASA has interest in developing HSRL technologies for measurement of aerosol extinction and backscatter relevant to studies of climate change, tropospheric chemistry, and air quality/human health. NASA Langley has developed a multi-spectral aircraft-based HSRL that it deploys for science-focused missions and satellite validation. The Earth Sun-System Technology Office (ESTO) has funded the development of a combined ozone differential absorption and high spectral resolution lidar (also being carried out at NASA Langley). The utility of a spaceborne multi-wavelength HSRL, providing independent measurements of extinction and backscatter at 355 and 532nm has been highlighted in peer-reviewed journals and a recent white paper to the National Academy of Sciences Decadal Survey defining future NASA mission priorities.

The current HSRL instrument fielded by NASA Langley operates at 532 and 1064 nm using the iodine vapor filter in the receiver for spectral separation of aerosol and molecular backscatter on the 532 nm channel. The HSRL applications cited in the aforementioned studies call for measurements at both 532 and 355 nm in order to derive key aerosol microphysical parameters (effective radius, concentration, index of refraction, and single scatter albedo) required for climate, chemistry, and air quality applications. Vapor filter cannot be applied at 355 nm, and HSRL measurements at that wavelength may only be accomplished via an interferometric receiver technique. Implementation of a Fabry-Perot based ranging interferometer receiver would enable the measurement of the aerosol and molecular backscattered spectrum at 355nm. MAC has developed and demonstrated a 355nm interferometer unit that employs a new adaptive interferometer measurement technique called the Programmable Edge Technique (PET), which makes use of a Digital Micro-mirror Device (DMD) in conjunction with a Fabry-Perot interferometer and two photo-multiplier tubes (PMT) per channel.

Technical Objectives and Work Plan: (Limit 200 words or 2,000 characters whichever is less)

The primary goal of this Phase 2 effort was to design and demonstrate a laboratory bench-top HSRL receiver that is capable of measuring aerosol scattering ratio and extinction coefficients. The specific objective were:

Objective 1: Specify full instrument requirements and conduct a Risk Assessment of the proposed concept

Objective 2: Design the Bench-top HSRL Receiver

Objective 3: Fabricate and Assemble HSRL Receiver

Objective 4: Test and Verify the HSRL Receiver

The development of the novel fringe imaging Programmable Edge Technique (PET) 532nm interferometer required more funds than were available. Thus, a contract modification allowed MAC to use the remaining funds to test a 355nm PET interferometer in a compact LIDAR system and evaluate its feasibility.

Technical Accomplishments: (Limit 200 words or 2,000 characters whichever is less)

MAC has successfully built a 355nm Programmable EdgeTechnique(PET) Fabry-Perot interferometer. The novel use of a DMD device to isolate fringe patterns has been demonstrated. This unit has demonstrated line-of-sight velocity measurements and was able to separate out the molecular and aerosol components. With additional algorithm development the device will be able to retrieve the aerosol-to-total scattering ratio and aerosol extinction coefficients.

NASA Application(s): (Limit 100 words or 1,000 characters whichever is less)

NASA and the National Oceanic and Atmospheric Administration (NOAA) are the most obvious and likely customers for systems incorporating enhancements from this Phase 2 work, as they have been past customers of MAC for Fabry-Perot-based LIDARs and receivers.

This research is directly applicable to the highly-modular HSRL system at NASA Langley Research Center. Subsequent development of this work will result in a system that can validate and extend the current HSRL system. A 532nm implementation of this work will allow cross-validation of the HSRL and PET techniques, as well as add extended capability for temperature, density, pressure and line-of-sight (vertical) wind velocity estimation.

Non-NASA Commercial Application(s): (Limit 200 words or 2,000 characters whichever is less)

Military applications for short- and long-range wind-sensing LIDARs include artillery accuracy improvement and optical air-data systems that replace traditional Pitot-static system on aircraft.

Non-military applications include clear-air turbulence sensing for commercial aircraft, meteorological monitoring of tropospheric and upper-atmosphere winds, and site selection and improved efficiency for wind farms.

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